

With the Author's Compliments

ON THE LIABILITY TO

INFECTION DURING SCHOOL-LIFE

AND ITS RELATIONSHIP TO

SANATORIUM ACCOMMODATION IN SCHOOLS

A Thesis

FOR THE

DEGREE OF M.D. IN THE UNIVERSITY OF CAMBRIDGE

BY

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THE rather indefinite title of this paper might be taken to justify some latitude in dealing with its subject-matter, and, while it is supposed that "statistics may be made to prove anything," I fear that it is often impossible to make them prove interesting, save by what artists term a certain breadth of treatment. It should be understood, however, that all the figures here quoted have been compiled with painstaking care; and I believe them to be accurate. The trustworthiness or otherwise of the conclusions which I venture to draw from them is another matter. This I wish to submit to the candid criticism of my readers' present judgment and future experience.

Fuller details on some points pertinent to the present enquiry may be found in the "Code of Rules for the Prevention of Infectious and Contagious Diseases in Schools," in "The Construction and Maintenance of School Infirmaries and Sanatoria," and in other publications issued by the Medical Officers of Schools Association.

ON THE LIABILITY TO INFECTION DURING SCHOOL-LIFE, AND ITS RELATIONSHIP TO SANATORIUM ACCOMMODATION IN SCHOOLS.

BY C. E. SHELLY, M.A. M.D. CANTAB.,

Medical Officer to Haileybury College.

In no respect does the medical officer of a school occupy a position more peculiar and more responsible than in this: He is concerned, if possible, to prevent, or at least to check—and he will inevitably be called upon to treat—outbreaks of infectious illness amongst a closely aggregated population whose individual members are particularly prone to this class of disease, and who are to a great extent unshielded by the protective influence of a previous attack.

A large school presents a mass of susceptible material much less diluted than is the case with an equal number of the general population; for the latter includes individuals of all ages, whose personal intimacy is much less close. Even if local sanitary arrangements are—as they should be—such as to exclude the idea of a local evolution of infectious disease, the avenues of infection from without are so many and so varied as to render it humanly impossible to safeguard all of them. In short, this susceptible material exists in a concentrated form; it is peculiarly exposed to attack; and infection, howsoever imported, has, therefore, a field specially favourable to its incidence and its extension.

Further, each boy in such a school represents a household elsewhere; possibly a large one, and perhaps one in itself comprising a large number of young and susceptible individuals. And boys who leave school at the end of term

carrying the virus of infectious disease with them thus become so many scattered foci for the possible origination of as many epidemics. While, then, we may compare the school to a collection of cartridges, for the most part loaded—not stored in a magazine but liable to ignition by any casual spark—so, also, we might liken most of the boys to so many fire-ships, liable—with a time-fuse just ignited, or themselves still smouldering—to be sent drifting down the broad tideway of the holidays into many a crowded port.

It is obvious, returning to my first simile, that the liability to, and the frequency of explosions—as well as their extent—are likely to be greatly influenced by the proportion which exists between the still loaded cartridges and those harmless empty ones that have been already fired. It might even prove very useful to know, or to be able to forecast, what this proportion is at any particular epoch, and therefrom to gauge the probable extent of inevitably recurrent disasters. It was with some such idea that the enquiries which form the basis of this paper were first undertaken. The investigation was limited to the commoner infectious maladies of adolescents—those which most frequently come before the school medical officer in an epidemic form, and which call for special provision by way of isolation in separate buildings. Moreover, I have considered only those maladies one attack of which is supposed to confer more or less immunity against a second; and my remarks refer almost exclusively to boarding-schools for boys. My object was to ascertain the proportion of schoolboys who, at the time of their entering the school, are *unprotected* by a previous attack of any of the several maladies in question; to note the extent of each epidemic; and to find whether this bore anything like a definite relation to the number of “suscepts” (if I may be allowed the term, which has at least a political precedent) in the school at the time. Other points of interest developed themselves incidentally; and the total results appeared to justify certain general conclusions which I hope may be of some value to both the profession and the public.

A paper embodying a series of questions on these points was issued to some five-and-twenty members of Medical Officers of Schools Association, whom I judged would be likely to possess

such information as I was anxious to obtain. To this paper I received replies more or less full, and in all cases of value. I have also carefully investigated the medical histories of some three thousand boys, who have passed through Haileybury College during the last five and twenty years; and the facts thus obtained have been made the basis of my calculations. Started in 1862, Haileybury, while lacking the valuable and venerable traditions of the older public schools, was at least fortunate in being untrammelled by a too rigid conservatism of established usage. To this is doubtless owing the freedom which has been, from its very commencement, judiciously allowed to its medical officers in all matters pertaining to the school's health; and the fact that I am able to refer to admission health-certificates, and to a precise record of all the illness treated there, during more than a quarter of a century. These statistics extend over a much longer period than do those of any other school with which I am acquainted; the records have been kept continuously from day to day of each term of each successive year; they exist in actual figures, and are no matters of surmise, of memory, or of probable averages; and the period of time which they represent is long enough to eliminate the undue influence of those recurrent variations in the character and extent of the commoner epidemics which may go far to invalidate conclusions drawn from the data furnished by less complete or less lengthened observation. It will, then, be understood why I may occasionally use these Haileybury statistics as a standard wherewith to compare those obtained from other sources.

First, then, I would ask attention to this TABLE No. I. It represents the entrance statistics of Haileybury for twenty-four years. The total number of boys who entered the school during that period is 2,598; the average age of entrance being about thirteen and a half years, and that of leaving about eighteen to eighteen and a half. The percentage of boys who at the time of their entrance into the school, were *unprotected* by a previous attack of the several diseases mentioned, is shown in column 3 of TABLE I. A.

TABLE I. A.

Statistics for	{ Sixteen years, 1863-79.	Eight years, 1879-87.	Twenty-four years, 1863-87.
Boys entered	1639	959	2598
<i>Unprotected from—</i>			
	Per cent.	Per cent.	Per cent.
Variola	1624 or 99·08 . . .	955 or 99·5 . . .	2579 or 99·2
Scarlatina	1183 or 72·18 . . .	718 or 74·86 . . .	1901 or 73·57
Rubeola	382 or 23·3 . . .	283 or 29·5 . . .	665 or 25·79
Pertussis	448 or 27·3 . . .	285 or 29·7 . . .	733 or 28·02

Dividing the twenty-four years into three periods of eight years each, but little difference was observable between the returns for the first and second of these epochs; and the combined returns for the first sixteen years, 1863 to 1879, are grouped together in column 1 of TABLE I. A. In several points this column contrasts with that for the last period of eight years, 1879—1887, column 2 in TABLE I. A. Thus, in the first place, it will be noticed that the percentage of *unprotected* is decidedly increased in the latter period. Had this been the case with such a disease as measles only, one would have been inclined to explain it on the supposition of a more general and more careful differentiation between it and *rötheln*, coincident with that wider appreciation of the characters distinguishing them which has spread amongst the public during recent years. But this increase of the *unprotected* obtains in the case of each and all of the maladies enumerated: and one is impelled to the conclusion that it is really due to an increasing education of the public in general hygiene; so that—owing to more careful prophylaxis, and to the earlier recognition of, as well as to the prompter and more efficient isolation of, “first cases”—a larger (and an increasing) proportion of children escape in infancy and early childhood; *i.e.*, in the pre-school age fewer contract these maladies than was formerly the case; and a greater number, therefore, enter school *unprotected*. This is a result highly encouraging to the medical officer of health, and to the family doctor; but it does not lessen the responsibilities or the anxieties of the medical officers of schools; and it cannot be regarded as tending to reduce the minimum of sanatorium accommodation required in a school. I may add that this progressive increase in the proportion of the *unprotected* at the beginning of school

life is shown elsewhere and in other ways. Thus, *e.g.* in a large school (350) to which only *young* boys are admitted, the entrance age was, some years since, raised by twelve months; but the average ratio of the unprotected (as from measles, for example) now stands practically at the same figure as formerly; and this in spite of the fact that twelve months of age, more or less, makes a very notable difference in the returns for any yearly period between the ages of nine and twelve.

The near equality of the returns for pertussis and for measles is striking for all periods; it is, moreover, very equably maintained throughout each of the twenty-four years noted; and I am tempted to think that, for this age at all events (13—14 *circ.*), the statistics of one may serve as a useful check against those of the other.

Fully twenty-five per cent. entered *unprotected* by any previous attack of *Measles*. Epidemics of this malady are common and extensive (*vide* TABLE I. B, Rubeola; and TABLE III.); and I hope to show that they seem to recur at pretty regular intervals and after a definite fashion.

TABLE I. B.—EPIDEMICS.

SCARLATINA.													
Number attacked	}	1	1	5	9	5	3	23 ¹	1	1	15 ²	7	2
Number in school		}	300	300	300	326	362	359	357	353	352	356	354
Percentage .	0·3		0·3	1·6	2·7	1·3	0·83	6·0	0·28	0·28	4·3	2·0	0·4
Rötheln—Percentages		2·5	0·26	0·82	3·1	4·10	5·74	3·08	22·6	17·6			
Mumps	„		1·6	4·1	9·8	2·24	6·26	3·6	4·6	18·2 ³	2·8	4·8	
Pertussis	„		From 1·3 to 2 per cent. of total boys in school.										
Varicella	„		0·82	1·6	1·36	2·1	1·25	3·1	3·08	0·52	0·6	3·8	1·0
RUBEOLA.													
		Jy. 1867.	Jy. 1868.	April 1870.	April 1871.	Dec. 1873.	Jy. 1875.	Jy. 1881.	Jy. 1883.	Jy. 1886.			
Number attacked . .		52	25	33	14	35	47	58	71	77			
Number in school . .		316	358	358	359	363	359	498	496	496			
Proportion		$\frac{1}{6}$	$\frac{1}{14}$	$\frac{1}{10}$	$\frac{1}{26}$	$\frac{1}{10}$	$\frac{1}{7}$	$\frac{1}{8}$	$\frac{1}{7}$	$\frac{1}{6}$			
Percentage		16·4	7·0	9·2	3·9	9·3	13·1	11·7	14·3	15·7			

¹ Special local cause active at the time.² Ambulant “Desquamator.”³ Began during the Measles Epidemic of 1883, and ran concurrently with it.

More than twenty-five per cent of boys entered unprotected from *Pertussis*; yet epidemics are relatively rare and of moderate dimensions amongst children from about the age of puberty upwards. As regards *Scarlatina*, more than seventy per cent. of boys are unprotected at entrance; yet epidemics are not common, and, being easily checked, are rarely extensive.

Small-pox.—It is noticeable that between 1863 and 1879, out of 1,639 boys no less than fifteen, or 0·91 per cent. had had the disease, while between 1879 and 1887, only four out of 959 boys, or 0·41 per cent. had similarly suffered. This is another proof of the increasing improvement in national health and health-seeking already alluded to. It has been stated (Guy, Harley, and others) that a previous attack of variola affords greater protection against small-pox than does vaccination: but that vaccination confers the greater protection against a fatal issue. It is notorious that a single primary vaccination confers an immunity the duration of which varies immensely in different individuals; and it is more than probable that its protective influence is apt to be quickly exhausted during the actively metabolic period of adolescence. It is desirable that every child should be re-vaccinated at or towards the termination of his school-life, for these reasons at least: and I find that of such re-vaccinations more than seventy per cent. have been successful—and some of these in boys who had previously been at least once re-vaccinated. But we should not lose sight of the fact long since pointed out by Sir George Paget, *viz.* that a convalescent from typhoid fever is almost always susceptible to vaccination—that its previously protective action has in fact been destroyed or neutralised by the more recent disease. Now adolescence is, *par excellence*, the period for enteric fever; I incline to the belief that many of the ill-defined febrile attacks with anomalous abdominal or cerebral symptoms are really abortive, or aborted, typhoid; and I think we may find in these cases another factor explanatory of that rapid exhaustion of the relative immunity conferred by vaccination during infancy, and an additional reason pleading for a routine re-vaccination before the school-life is ended.

Let me now direct attention to TABLE II., in which thirteen large public and private schools are arranged in the order of

TABLE II.

School.	Average age at entrance.	Percentage of boys who enter unprotected by—					
		Scarlatina.	Rubeola.	Rötheln.	Mumps.	Pertussis.	Varicella.
A	8-10	82·3	33·1	94·7	85·2	41·8	58·6
B	10½	80	65	80	60	30	40
C	11	70 ^a	45 ^a	70 ^a	70 ^a	33 ^a	50 ^a
D	11½	?	?	?	?	?	?
E	9-14	75·9	27·8	?	74	42·7	?
F	12	72·35	23·53	?	75·9	40	52·9
G	12	?	?	?	?	?	?
H	13	67	19	?	?	31	?
I	13	?	?	?	?	?	?
K	13	?	?	?	?	?	?
L	13½	80	24	?	?	32	?
M	13½	74·86	29·5	?	?	29·7	?
N	14½	75	16·9 ^b	96·9	72·6	43·4	55·1
O	19	8	3	10	10	15	10

^a, "Approximate" returns. ^b, Boys come chiefly from other large schools.

the age of the boys at entrance. Parallel with the rise in the age of entrance, will be noted a pretty constant increase in the ratio of the protected. But, modifying the all-important factor of age, is to be noted the potent operation of social position. Contrast, for instance, A and B. The former is a school which, by the terms of its existence, is largely recruited from families that have been visited by misfortune or broken up by disease and death. Boys come to it, therefore, at the age of about nine, from conditions which have been, on the whole, *not* the most favourable to the safeguarding or the preservation of health. No infectious malady is more apt to spread under such circumstances than *measles*; and the percentage of those already attacked by that disease is sixty-seven. B is a private boarding school: its boys all come from families in a good position in life, and in affluent circumstances; every care is possible, and is no doubt rendered to them individually at home; and they come direct from home without having gone through any preparatory school. Hence, although the entrance age is at least eighteen months above that of A—and probably equal to that of E—only thirty-five out of every hundred have had such a disease as rubeola. Putting this exceptional contrast aside, all the schools are on a fairly equal footing as regards social status. And it will be

seen that, so far as their statistics are obtainable and reliable, *age* affords a very fair basis for estimating the liability to infection for the several diseases mentioned. The returns in these tables are not so full as I could wish, nor are they so complete as those which I trust some other chronicler may be able to furnish, say a decade hence. As regards F, I note the relatively small number of those unprotected by measles; and I cannot help suspecting that some boys may have been said by their parents to have had measles when what they had really suffered from was r  theln. The figures (23.53 per cent.) are barely more than half those for whooping-cough (40 per cent.); and I find, also, that in an epidemic of measles at this school, the number attacked would indicate a higher entrance-rate (*vide postea*). A similar suggestion applies to H; where, also, the average proportion attacked in measles epidemics corresponds with that shown by schools in which the unprotected at entrance number 25 to 30 per cent. N shows a small percentage in this column (16.9 per cent.); but its boys "come chiefly from other large schools," and have therefore been already exposed to a double ordeal before they are drafted into this establishment, which occupies a special educational position. For O the entrance-age is nineteen years. Its entrance statistics remind us how thoroughly and widely measles works during early adolescence; and shows, too, how many adults have already suffered from scarlet fever—as individuals at all events—though of boys *  t.* 15, less than 50 per cent. have had the disease.

It appears that the great majority of boys in a large school tend to get through the list of ordinary self-protecting infectious ailments by the age of about 15 years. The chief exception would appear to be scarlatina (compare O, TABLE II.). Probably a few at least are protected by mild abortive attacks—often described as simple febricula—which may represent inoculation by an attenuated, but sufficiently powerful, "vaccine."

Measles seems to be very strongly self-protecting up to the age of twelve to thirteen years at least. The medical officer of a large school of some 350 boys, subject to frequent epidemics of rubeola, tells me that he has never met with a genuine second attack in a child under 12. Several such have been reported; but careful investigation has in each case disproved the asser-

tion. I should regard an alleged second attack of measles before puberty, as strong evidence that one or other illness was really r  theln.

Now, a few words on the facts revealed by a study of these maladies in their epidemic form (*vide* TABLE I. B—with which may be contrasted TABLE III. and TABLE II.). As regards *Scarlatina*, proportions and percentages are of comparatively little moment, since the extent of an outbreak of this disease is mainly dependent upon the virulence or otherwise of the malady, and—especially—upon the health-conditions of the population and district concerned; together with the means adopted or neglected for the early and effectual isolation of cases. Of the six chief outbreaks at Haileybury, three (including twenty-one cases) occurred in the winter and early spring months, and three in the summer; but these latter happen to have been the most extensive, and furnish between them forty-three cases. The large outbreak in July, 1871, was traceable to a special local condition obtaining in the immediate neighbourhood of the school at the time. That of July, 1873, was kept up—as it had probably been started—by a boy who had returned to school after the holidays in nominal good health, but who walked about for some time shedding desquamating epithelium before his condition was detected.

Scarlatina, of course, demands provision for prompt and effectual isolation; but it would appear that an allowance of about 2 to 3 per cent. of the total number of pupils in the school may suffice for this disease.

R  theln is often deemed beneath the dignity of special sanatorium accommodation. Yet it is a disease which may produce a decidedly debilitated condition of the system; it appears, at least, to predispose to certain other maladies; and, in its common epidemic form, it may do much to dislocate the work of a large school. It is, however, rarely coincident with measles, though it often follows or precedes that disease; and if fair provision exists for meeting the average proportions of a measles epidemic in any school, this will probably suffice for r  theln. For, if r  theln epidemics are apt to be rather more extensive than are those of measles (*vide* TABLE I. B, and TABLE III.), it should be remembered that convalescence from r  theln is commonly

TABLE III.

School.	Average Entrance Age.	SCARLATINA.			RUBEOLA.			RÖTHELN.			MUMPS.			PERTUSSIS.			VARICELLA.			Total Days in School.	These are Statistics for the last
		UE.	Mx.	Av.	UE.	Mx.	Av.	UE.	Mx.	Av.	UE.	Mx.	Av.	UE.	Mx.	Av.	UE.	Mx.	Av.		
A	8-10	82.3	12.5	2.63	33.1	23.75	22.1	94.7	28.0	21.87	85.2	42.6	29.03	41.8	13.12	3.5	58.6	13.3	6.55	340	10 years
B	10½	80a	1.6		65	25	21.6	80	54		60	48		30	?	?	40	36		60	12 years
C	11	70a	1.6	1.08	45a	27.6	25.5	70a	?	?	70a	48.6		33a	?	?	50a	?	?	182	9 years
D	11½	?	4.17	3.53	?		11.06	?	0	0	?	0	0	?	0	0	?	0	0	768	17 years
E	9-14	75.9	0	0	27.8	22.5		?	0	0	74	0	0	42.7	0	0	?	0	0	400	5 years
F	12	72.35	0	0	23.53	20		?	?	?	75.9	?	?	40	?	?	52.9	?	?	200	?
G	12	?	7.1*		?	20*		?	30*		?	30*		?	5*		?	3.3*		300	?
H	13	67	0.017		19	14.9	14.78	?	25.26		?	12.45	10.69	31	?	?	?	1.05	0.52	570	6 years
I	13	?	1	0.4	?	14.4		?	40.4	26.7	?	?	?	?	0.6		?	0.4	0.3	500	3 years
K	13	?	2		?	"about 10"		?	"about 10"		?	2.5		?	?	?	?	2.5		400	?
L	13½	80	4.7	1.7	21	24.7	14.5	?	?	?	?	?		32	?	?	?	?	?	400	15 years
M	13½	74.86	2	1.2	29.5	15.7	13.8	?	22.6	20.1	?	18.2	8.2	29.7		1.0	?	3.8	1.4	500	12 years
N	14½	75	0	0	16.9	7.4		96.9	9.09		72.6	20.9	20.8	43.4	0	0	55.1			118	5 years
	19	8	3.1		3	5.6		10	4.9		10	5.6		15	0	0	10	0	0	124	5 years

Under the head of each disease is given (1) the *Percentage* of boys who are, at entrance, unprotected by a previous attack, = UE.; (2) the *Maximum Percentage* (out of total number of boys in the school at the time) attacked in an epidemic = Mx.; (3) the *Average Percentage* attacked in "full-scope" epidemics = Av.

a, "Approximate." * "These figures from memory."

very rapid, and that each r  theln case is usually detained for a much shorter time than is a measles patient ; so that, during an epidemic, beds are so much the sooner cleared and available for the reception of fresh patients. On looking through the records of some large epidemics of these two maladies, I find that the periods of treatment were almost precisely as two to three in the two cases. Well-marked incubation periods, of eleven and of fourteen days respectively, were observed in connexion with r  theln.

Mumps is responsible for many and extensive epidemics before puberty. After the age of fourteen or thereabouts, its incidence is much less regular, and—as a disease by itself—its epidemics are not often very large. But it would appear that if mumps occur coincidentally with measles, and so early in a school-term as to allow the disease “full scope,” the number affected may equal or even exceed the number attacked by measles ; and a similar observation applies, though possibly with less force, to coincident epidemics of mumps and r  theln. The fact that exhalation from the air passages is a mode of infection common to all three maladies may throw some light on this point. Incubation periods of nineteen days (in three cases), of twenty days (one case), and of twenty-two days (in two cases), were noted at Haileybury : moreover, several cases of undoubted second attacks, not mere relapses, have come under observation.

Outbreaks of *Pertussis* are irregular and conform to no obvious rule. The disease does not give rise to extensive epidemics in schools, the entrance age for which approaches that of puberty ; and in the face of this experience it becomes still more interesting to note the nearly equivalent rates at which children become protected by measles and by whooping-cough.

Young children readily take *Chicken-pox* ; but, in the schools of higher age, at all events, it does not give rise to extensive epidemics, and for reasons similar to those already noted in the case of scarlet-fever—*i.e.*, the earlier cases are easily detected and can therefore be promptly isolated before they have reached that stage of development (which is comparatively late) at which they become most potent for infecting others.¹

¹ I am aware that some observers maintain that varicella is most infectious during its pre-eruptive stage : the facts within my own experience do not support this view.

Epidemics of varicella, though small in extent, are far from uncommon, and the disease is often contemporaneous with others. A sanatorium allowance of 2 per cent. is probably ample for schools which have a minimum entrance-age of twelve years. Incubation periods of sixteen days and of seventeen days were observed at Haileybury.

I have reserved the fuller consideration of *Measles* until now because it is essentially the type of an exanthem which, being infectious during its pre-eruptive stage, cannot be stamped out, and which therefore furnishes, as a rule, extensive epidemics. At present I know of only one large school of several hundred boys which claims to have had a complete measles "epidemic" of *one* case only. I sincerely hope that our vigilance may be so perfected, and so fortunate, that other medical officers of schools may hereafter achieve a like happy experience. But at present we must take things as we find them; and the statistics which confront us under this head do not yet furnish ground for hopeful anticipations.

Referring to TABLE I. B, which deals only with Haileybury, it will be seen that (omitting the outbreaks which, beginning late in the term, for instance, did not have opportunities of attaining their full dimensions) we get a total of 338 cases amongst 2,523 boys—*i.e.*, 1 in every 7·4 boys, or 13·4 *per cent.* for the whole twenty-four years. The first period of sixteen years (when the unprotected entry was 23·3 *per cent.*) gives 132 cases amongst 1,033 boys—*i.e.*, 1 in 7·8, or 12·8 *per cent.* The last period of eight years (when the unprotected entry was 29·5 *per cent.*) gives 206 cases amongst 1,490 boys—*i.e.*, 1 in 7·2, or 13·8 *per cent.*

In the course of the above epidemics there appeared to be well-marked incubation periods of twelve, thirteen, twelve, and fourteen days in different cases: these were determined by a careful consideration of the circumstances at the beginning of the several outbreaks.

When the *maximum* age of entrance into a school does not exceed twelve years, fully twenty-five *per cent.*, or one-fourth of the whole school, will probably be attacked in any "full scope" epidemic of measles (*vide* TABLE III.). This Table also well bears out the results of our Haileybury experience, which

is to the effect that when the entrance-age lies between twelve and fourteen years, one-seventh of the whole school, or about fourteen *per cent.*, is the normal sum of a full outbreak.

Investigation from another standpoint indicates that rubeola epidemics are prone to occur whenever the susceptible material has so accumulated as to represent about one-third of the total number of pupils in the school at the time, or $\frac{T}{3}$. We have, then two "empirical laws":

I. "*An epidemic of measles may be looked for whenever the total number of unprotected boys equals one-third of the total number in the school*"—(i.e., when the susceptible material is so concentrated as to form a readily explosible mass).

II. "*In such an epidemic (if it have full scope, by beginning, for example, early in a term), three-sevenths of the nominally unprotected*¹ (i.e. $\frac{3}{7}$ of $\frac{1}{3} = \frac{1}{7}$ of the total boys) may be expected to be attacked." [N.B.—This proportion equals about 14 *per cent.* of the whole school. But as some patients will be well—and their beds therefore available for others—before the end of the epidemic, 10 *per cent.* of sanatorium accommodation might be enough to allow under this head. It should be noted, however, that such an allowance makes no provision for cases of another and concurrent epidemic malady.]

These two laws may be combined thus:—"Let T stand for the total number of boys in a large school, the entrance age to which is about thirteen years. When $\frac{T}{3}$ are nominally unprotected by a previous attack of measles, an outbreak of measles may be expected to occur; and in this outbreak $\frac{3}{7}$ of $\frac{T}{3} (= \frac{T}{7})$ will be attacked."

[I may add that, as regards rötheln, three-fifths of U T will probably be attacked—U being the co-efficient of *unprotection*, i.e. $\frac{1}{3}$, $\frac{1}{2}$, &c., as the case may be: perhaps for rötheln U may generally be taken $= \frac{1}{3}$, and then $\frac{3}{5}$ of $\frac{T}{3} = \frac{T}{5}$ or 20 *per cent.* = the number likely to be attacked in a full-scope epidemic of German measles.]

¹ The "nominally unprotected" are those who appear to be unprotected according to the returns (entrance-certificates, &c.) commonly accessible.

As a corollary it may be stated that—

III. "If the epidemic prove much less extensive than it should have been by Law II. (owing, *e.g.*, to its beginning about the middle or towards the end of a term), the next epidemic may be looked for after less than the usual interval," *i.e.* as soon as the "explosive ratio" $\left(\frac{T}{3}\right)$ is again reached. I believe that this outbreak of an epidemic whenever the susceptible material reaches a certain proportion of the whole mass explains the commonly admitted tendency to the recurrence of the disease in schools at pretty regular intervals of time.

These empirical formulæ have been deduced from a study of the statistics furnished by numerous schools. The figures of the Haileybury records happen to be the most complete, though not, I think, more conclusive than the others; and I venture therefore to reproduce a partial summary of them here. In a school of five hundred boys, who enter *æt.* 13 *circ.*, and leave *æt.* 18 *circ.*, the period of school-life averages five years. About one hundred boys enter annually, and of these at least 25 per cent. are unprotected from measles; one hundred boys leave every year, and of these at least 5 per cent. will still be unprotected. So that, in round numbers, twenty boys are added every year to the rubeola-unprotected population of the school. [Probably, *vide* Table I., it would now be more accurate to take a higher net percentage of unprotected; but the difference may be allowed to stand as a set-off against those few individuals who (while not recorded as such) become protected by attacks contracted and sustained during the holidays.]

Looking at the figures given under measles in Table I. B, it is seen that the chief epidemics occurred at intervals of about two to three years. When an interval of about twelve months only intervenes between successive outbreaks, the second epidemic is apt to assume comparatively small dimensions; *e.g.* 52 cases $\left(\frac{T}{6}\right)$ in 1867 followed by only 25 $\left(\frac{T}{14}\right)$ in 1868; 33 cases in 1870, 14 in 1871. When the interval extends to about three years, the normal proportion $\left(\frac{T}{7} \text{ or } 14 \text{ per cent.}\right)$ tends to be assumed. This comes out more clearly on further analysis;

in 1867, 105 boys, or about $\frac{T}{3}$, were *unprotected* (U) by a previous attack of measles; 52 ($=\frac{3}{7}$ of U) are protected by the epidemic of that year, leaving 53 still unprotected. Add 16 for unprotected entries in 1868, and we have a total of 69 U, of whom 25 become protected by an imperfect epidemic, leaving 44 U. Add another 16 for 1869, and 20 for (the larger entry of) 1870, and the total of 80 U is attained. An epidemic now protects 33 ($=\frac{3}{7}$ of U) leaving a balance of 47 U. Add 20 for 1871, and we have 67 U; a partial outbreak protects 14, leaving a balance of 53 U. Add 40 more for the two years 1872 and 1873, and $U = 93$; an epidemic protects $\frac{3}{7}$ of U (or 35) and leaves 58 U. To these would be added about 20 in 1874, and another 20 (*i.e.* 20 per cent. of the entries for the year) in 1875, making a total of 98 unprotected boys, which equals $\frac{T}{3.6}$. The epidemic occurs, protecting 47, or as usual, about $\frac{3}{7}$ of U, and leaving 52 U. By the end of 1881 there were about 162 unprotected in the school of 500 boys (equal to nearly $\frac{T}{3}$); the epidemic protects 58 (not quite $\frac{3}{7}$ of U, or $\frac{1}{7}$ of T), leaving 104 U. Add 50 more unprotected for 1882 and 1883, and the total becomes 154 U, or nearly the critical $\frac{T}{3}$; and another epidemic protects 71 (a little over $\frac{3}{7}$ of U), leaving 83 U. Add 25 more for each of the next three years, 1884-85-86, and the total reaches 158 (or $\frac{T}{3}$), when another epidemic protects 77 (rather more than $\frac{3}{7}$ of U), and leaves 81 unprotected. It is to be noted that the number attacked during an epidemic will greatly depend upon whether it begins by one or more foci; also, whether an initial case starts the outbreak quite at the beginning or towards the end of the first fortnight of the term; and, further, upon whether

this initial case has a wide or a narrow circle of associates ; and whether these latter are mostly already protected against the malady or not. It is held that a case of ambulant rubeola in which the catarrhal symptoms—sneezing especially—are well marked, is likely to have a widely-felt infective influence. Nor should we ignore the character of both the preceding and the prevailing meteorological and other conditions of the environment, which probably affect susceptibility to an appreciable extent.

Of the nine principal epidemics of rubeola noted in Table I. B, no less than six, with a total of 330 cases out of the whole 412, or 80·09 per cent., occurred during the summer months ; and only three outbreaks, with but eighty-two cases, altogether, during the spring, autumn, and winter months. I do not know whether this is the usual experience of school doctors ; it is opposed to the dictum of Hirsch who, in his *Handbook of Geographical and Historical Pathology*, asserts that measles “is a disease principally of the cold season in all climates.” This statement is doubtless true as a general expression of the incidence of the disease on the population at large ; but I can easily conceive how, in schools, epidemics of measles are apt to become extensive in the warmer months ; since, during the summer, a patient in the prodromal stage readily persuades himself that what he takes for a slight “head cold” will soon pass off of itself, and his malady does not come within the ken of the medical officer until it is thoroughly pronounced, and not until after he has had time and opportunity to spread it widely amongst his fellows.

It is still often urged that it is needless, and that it would be useless to attempt, to provide special sanatorium accommodation for measles. I am unable to endorse that opinion. The disease is one which seriously interferes with the patient’s educational programme : it commonly induces a certain amount of physical debility, and may predispose to other maladies. Are we justified in sanctioning the neglect of what is at once the most reasonable and the most efficient means usually at our command against the extension of an epidemic ? If a large ward or dormitory, or similar building can be promptly and effectually utilised as a hospital in an emergency, well and good. But I think it foolish

to suppose that the isolation of patients can be assured in such a case, as it can in any properly administered sanatorium. Some of my colleagues amongst the medical officers of schools have had acquaintance with outbreaks of measles of a type so virulent that they would have felt it criminal to do less than attempt in every possible way to separate the obviously infectious from the presumably healthy. And, even with a mild type of the disease, each boy attacked by the malady at school represents a loss in health, temporarily, at all events; a loss of educational opportunities at the time of life when they are most valuable; and, practically, a loss of the money which had been paid to secure those advantages. Thus, for example, an epidemic of measles affecting seventy boys represents a total loss of at least two thousand working days. The prompt and thorough isolation of each case as it arises at least limits the activity of as many foci of infection; and must therefore have an influence in curtailing the epidemic. If proof of this statement were needed, I might cite on the one hand that extreme represented by the dispersion of the school for the holidays, when the epidemic, as such, ceases, because the liability of contact between sick and healthy boys is reduced to zero; while on the other hand I recall an experience of life in a large foreign city where an outbreak of a mild type of measles amongst a section of the population, whose burial rites were not less opposed than was their general ignorance to hygienic rules, kept the total death-rate for a month at over sixty per thousand, and for one week raised it to nearly ninety per thousand.

I hold, then, that we should neglect no precaution against the spread of even measles in a school; in other words, that sanatorium accommodation should be provided for this disease. Nor is the amount demanded under this head really excessive, seeing that, for reasons already given, it includes all necessary provision for r  theln. For large boarding-schools of over three hundred boys with a *minimum* entrance age of twelve years, I have, as previously stated, placed it at 10 per cent. of the total number of pupils. Add, as already noted, 2 per cent. for scarlatina; 5 per cent. for mumps; 2 per cent. for chicken-pox, and, say, 1 per cent. for such a disease as diphtheria, and a total of 20 per cent. is reached. I do not believe that this is by a

fraction too great for the needs of a large school, under the average existing conditions; and it must be remembered that, as the percentage of the unprotected entries for all infectious diseases seems to be steadily and continuously rising, we are not likely to want less in the future than is found to be needful now.

It is not requisite that the whole of this accommodation should be provided in a building constructed in the same permanent and substantial manner throughout; from one-half to one-third of the amount named may fairly be of a semi-temporary character, as *e.g.* a semi-detached *annexe* built of wood or of corrugated iron with double walls; and this, during lesser outbreaks, would serve admirably as a play-room for convalescents. Further, the existence of what is known as the "house-system"¹ in such a school tends at least to *delay* the progress of an epidemic, and may be considered to lessen the amount of sanatorium accommodation required by a number of beds equal to from 3 to 4 per cent. of the total pupils. Again, the attendance of a considerable proportion of day scholars is favourable to the occurrence of epidemics more frequent, but of smaller dimensions; and hence it may be taken that the amount of sanatorium accommodation required will be less than that needed if no day boys attended, by a number of beds equal to at least 2 per cent. of the total number of boarders in the school. Finally, whenever a large school is subdivided into a junior and a senior establishment, the latter is thereby greatly protected against the incidence of epidemic disease; and it is obvious that, if the senior and junior schools be conducted as distinct establishments, there will be a very great disproportion as regards the amount of sanatorium accommodation severally needed in the two cases. But taking as a common and convenient example a large boarding-school containing 300 boys or more; with an entrance age of between twelve and fourteen years, the average age of leaving school being about eighteen, it may be stated that, *in order to provide proper accommodation for treating full outbreaks of epidemic illness, and allowing for two or more infectious diseases being epidemic in the school at the same time*, the number of beds available in the sanatorium should equal 20 per

¹ The several "houses" being distinct and isolated buildings.

cent. of the total number of boarders. (This allowance does not include the provision needed for servants, which even in large schools will be very small indeed.)

At least the medical officer of such a school should ask for nothing less ; he may not always be so fortunate as to get what he asks for ; but in this case he will be the better able to discharge his duties if and when he does.

I am conscious of many shortcomings in what has been advanced in the foregoing pages. The data at my command are not as full or as extensive as I could have wished, and my conclusions—which chiefly apply to one class of school only—must be regarded as merely tentative ; they are subject to modification with the acquisition of fuller knowledge, and liable to change with the advance of national hygiene. Yet I believe there is a mine of valuable truths in the statistics which ought to be forthcoming on this subject from every school. And I hope that in the not distant future it may be possible to formulate rules much more definite than any I have hinted at from data more accurate and more accessible than mine. Let me again thank those gentlemen who, with a ready courtesy for which I was prepared, but, in many cases, only by a process of laborious research which I regret they should have had to undertake, were good enough to furnish me with those valuable figures and memoranda of which I have made so free a use. And, “as in private duty bound,” I wish here to acknowledge my indebtedness to the governing body of the school to which I am directly attached. Before the idea of this paper had been born, and when I was working at the school statistics of entrance and illness to see what they might teach, I asked the late secretary of Haileybury whether there would be any objection to my making public use of the facts at my command, should a suitable opportunity present itself for doing so. My letter was laid before the council of the college at its next meeting ; and it was decided unanimously and without demur that, as the school medical officer, I was at liberty to make any use, public or private, of all such facts connected with the sickness, health, and other details of the school as came within my official purview, provided only that their publication seemed calculated for

the benefit of the school itself *or* of the public at large. In taking this course, it may be contended that the council did no more than was right ; on the ground that no school is entitled to a selfish monopoly of the scientific truths which its existence reveals, and that it can but claim to hold and use them as a trustee for the public benefit in which it shares. But it is not every corporate body which is so prompt to see and so ready to do its duty in such matters ; and I think that the votaries of sanitary science, at all events, will be the last to withhold their approval of a course which is consonant with their own teaching.

